Vehicle to Everything (V2V,V2I,V2X, C2C,C2X)

ROHDE&SCHWARZ

COMPANY RESTRICTED

R&S test solutions for Automotive

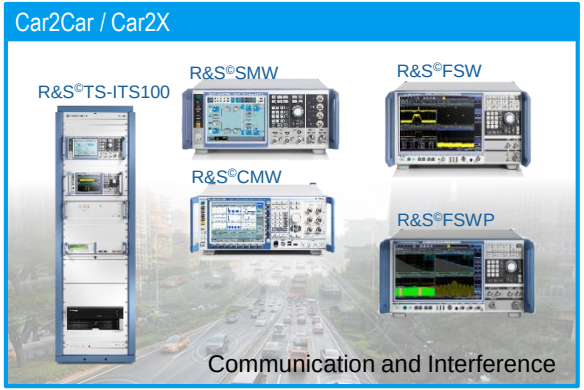
GNSS / eCall

EMC

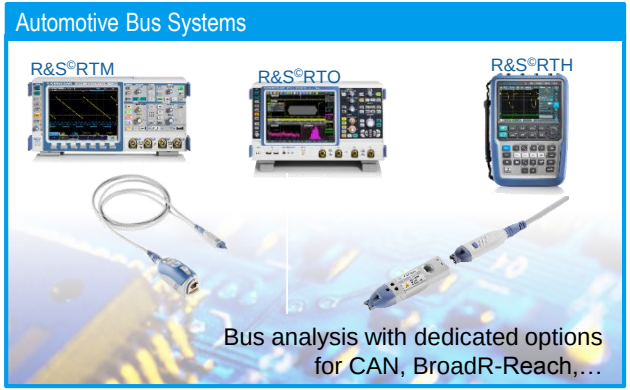
Audio / Video / Infotainment

Automotive Radar Solutions

Car2Car / Car2X



Automotive Bus Systems



Research & Development

- Transmitter tests
- Receiver test

Design & Validation

- RF Parametrics
- Co-existence
- Functionality
- Performance
- Power analysis

Pre-Compliance & Compliance

- Standard compliance
- Regulator compliance

Manufacturing

- Calibration
- Verification
- Go / NoGo

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V2X Communications

- A car2car module of the following components:
  802.11p chip, 2 tx/rx antennas (to avoid package losses), GNSS receiver and CAN / USB interface.

Source: cohdawireless.com

- General T&M Requirements:
  - Repeatability (not only drive tests)
  - Generation and Analysis of 2 x 5.9 GHz 11p test signals
  - PER testing
  - Multipath simulation

What do we need to test in R&D?

More Detail

Goal: Verify basic receiver and transmitter performance in a realistic but repeatable environment including fading.

- Transmitter
  - Channel Power ACLR
  - Spectrum Emission Mask
  - Occupied Bandwidth
  - CCDF
- Receiver
  - Minimum input sensitivity (sensitivity of the DUT at very low input levels)
  - Maximum Input Level (demodulate an 11p signal with a high input level)
  - Adjacent and Nonadjacent channel rejection (demodulate a signal in the presence of an interfering signal)

Research & Development	Design & Validation	Pre-Compliance & Compliance	Manufacturing
Transmitter tests Receiver test	RF Parametrics Co-existence Functionality Performance Power analysis	Standard compliance Regulator compliance	Calibration Verification Go / NoGo

What do we need to test in Design and Validation?

More Detail

Goal: Ensure that a product or system fulfills the defined user needs and specified requirements, under specified operating conditions.

- RF Parametrics
- Co-existence
- Functionality
- Performance
- Power analysis

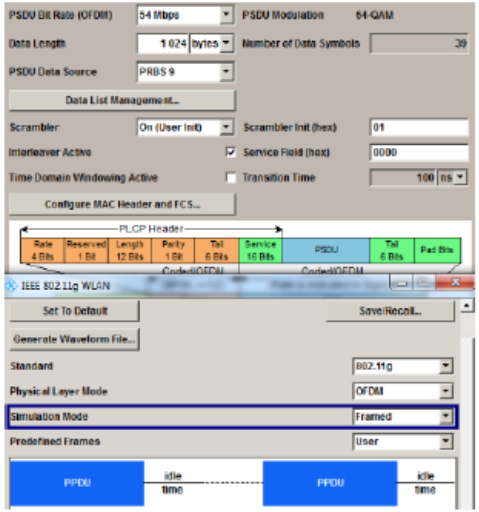
What do we need to test in Design and Validation?

More Detail

Rx Quality Analysis

R&S®WinIQSIM2

Configuration of 802.11 waveforms



802.11 a/b/g/n/j/p (option KW650)
802.11 ac (option KW656)

Tx Measurements

Standard RF measurements:

- Power Measurements:
  - Burst Power
  - Power vs. Time
- Modulation Accuracy:
  - EVM
  - Frequency Error
  - Symbol Clock error
  - Chip Clock Error
  - I/Q quality
- Spectrum Analysis:
  - Spectral Flatness
  - Transmit spectrum mask
  - Occupied bandwidth

802.11 a/b/g (option KM650)
802.11n (option KM651)
802.11p (option KM655)
802.11 ac (option KM656)

Research & Development

- Transmitter tests
- Receiver test

Design & Validation

- RF Parametrics
- Co-existence
- Functionality
- Performance
- Power analysis

Pre-Compliance & Compliance

- Standard compliance
- Regulator compliance

Manufacturing

- Calibration
- Verification
- Go / NoGo

Pre-compliance and ComplianceTesting?

More Detail

Goal: Verify the device passes the necessary conformance requirements

- Standard compliance
- Regulator compliance

TS-ITS100 - System software (Europe)

Regulatory tests according to R&TTE* ETSI EN 302 571

ITS-G5A Test Cases

- 5.3.2.3.2 Carrier Frequencies
- 5.3.3.3.2.1 RF output power at the highest level
- 5.3.3.3.2.2 Power Spectral Density
- 5.3.4.3.2 Unwanted emissions outside 5 GHz ITS band
- 5.3.5.3.2 Unwanted emissions inside the 5GHz ITS bands
- 5.3.6.3.2 Spurious Emissions
- 5.3.7.3.2 Selectivity
  (contains Adjacent, Non-adjacent and Blocking test case)
- 5.3.8.3.2 Sensitivity

Available on TS-ITS100

Testing to protect other regular radio services

TS-ITS100 - System software (Europe)

Car-2-Car Communication Consortium (C2C-CC)

Performance tests

- To ensure proper services additionally **performance tests** are required
- ETSI and C2CCC (ETSI TC ITS WG4) are discussing currently the specification of such performance tests inclusive a certification program
- Tests under discussion for
  Receiver minimum performance requirements
  - Receiver sensitivity (under fading conditions)

  Available on TS-ITS100
- Decentralised congestion control (DCC) minimum performance requirements
  - Channel load threshold verification
  - Channel load measurement accuracy
  - Channel load quality under time-varying, multipath propagation conditions

  Available on TS-ITS100

TS-ITS100 - System software (Japan)

Regulatory tests according to ARIB STD-T109

2.1 The test item for the technical requirements for the physical layer

- 2.1.1 Modulation accuracy
- 2.1.2 Reception sensitivity (Packet error rate)
- 2.1.3 Maximum input power for reception
- 2.1.4 Blocking characteristics

Available on TS-ITS100

TS-ITS100 - System software (Japan)

Regulatory tests according to TELEC T257

1 The test item for the technical requirements for the physical layer

- 1.1.1 Frequency tolerance
- 1.1.2 Occupied bandwidth
- 1.1.3 Antenna power tolerance
- 1.1.4 Intensity of spurious or unwanted emissions
- 1.1.5 Transmission data rate
- 1.2.1 Limits of incidentially produced radiation
- 1.3.1 Interference prevention function
- 1.3.2 Carrier sense function
- 1.3.3 Transmission time control function

Available on TS-ITS100

More Detail

TS-ITS100 - System software (USA)

Test cases according to IEEE 802.11-2012

- 18.3.9.2 Transmit power levels
- 18.3.9.3 Spectrum Mask
- 18.3.9.4 Transmission spurious
- 18.3.9.5 Center frequency tolerance
- 18.3.9.6 Symbol clock frequency tolerance
- 18.3.9.7.2 Transmitter center frequency leakage
- 18.3.9.7.3 Transmitter spectral flatness
- 18.3.9.7.4 Transmitter constellation error
- 18.3.10.2 Receiver minimum input sensitivity
- 18.3.10.3 Adjacent channel rejection
- 18.3.10.4 Nonadjacent channel rejection
- 18.3.10.5 Receiver maximum input level
- 18.3.10.6 CCA requirements
  (depends on the availability of CCA values in the DUT API)
- 18.3.10.7 Received Channel Power Indicator Measurement

Available on TS-ITS100

Research & Development	Design & Validation	Pre-Compliance & Compliance	Manufacturing
▌Transmitter tests ▌Receiver test	▌RF Parametrics ▌Co-existence ▌Functionality ▌Performance ▌Power analysis	▌Standard compliance ▌Regulator compliance	▌Calibration ▌Verification ▌Go / NoGo

What do we need to test in Production?

More Detail

Goal: Automated verification of device function, at the end of the manufacturing process.

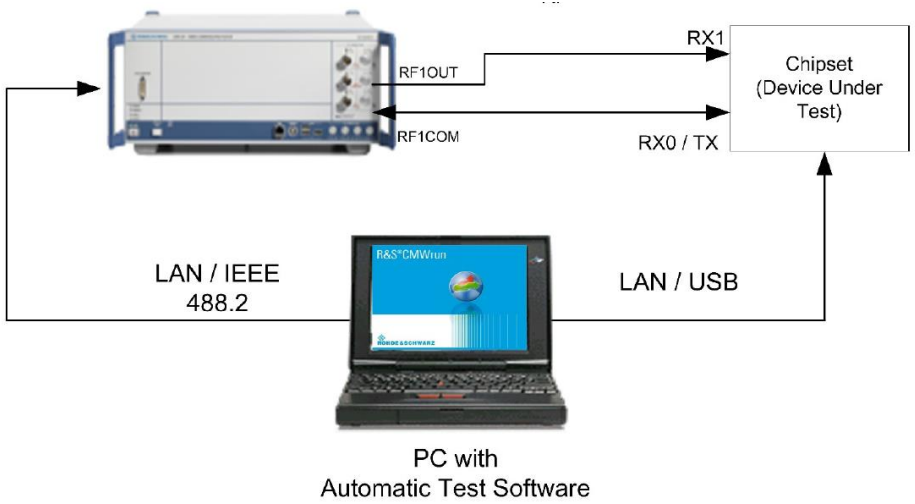
- Reference Calibration Tests
  - RSSI parameter
  - TX Output power
  - Flexible settings of frequencies
- Reference Verification Tests
  - RSSI
  - CINR
  - Constellation Error (EVM)
  - TX Output PowerGo / NoGo

- Go/No Go

What do we need to test in Production?

More Detail

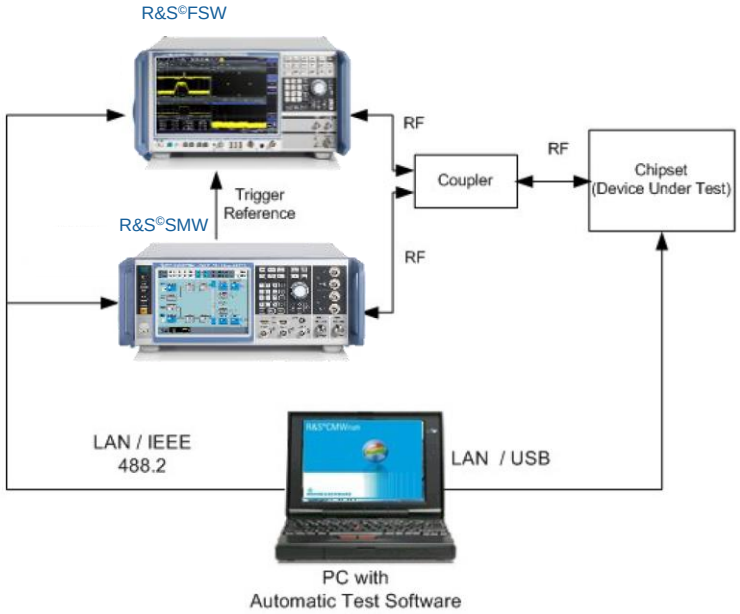
The Communication Tester combines signal analysis and signal generation in a single instrument. For time optimized RF calibration in non-signalling mode, the tester provides fast transmitter measurements and a versatile arbitrary waveform generator for receiver testing.



What do we need to test in Production?

More Detail

An alternative setup is based on Spectrum Analyzer and a Signal Generator remote-controlled via IEEE 488.2 (GPIB) or LAN.



R&S test solutions for Automotive

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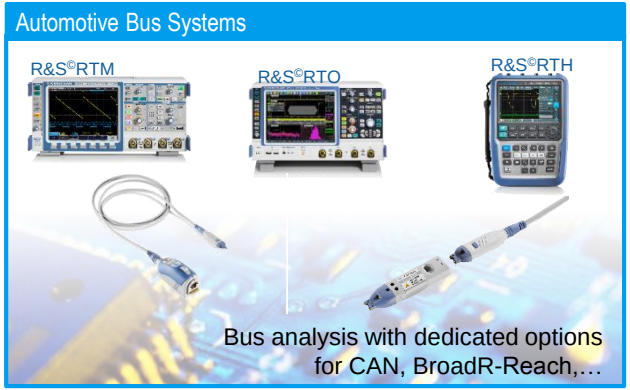

The Technology behind V2X

Index

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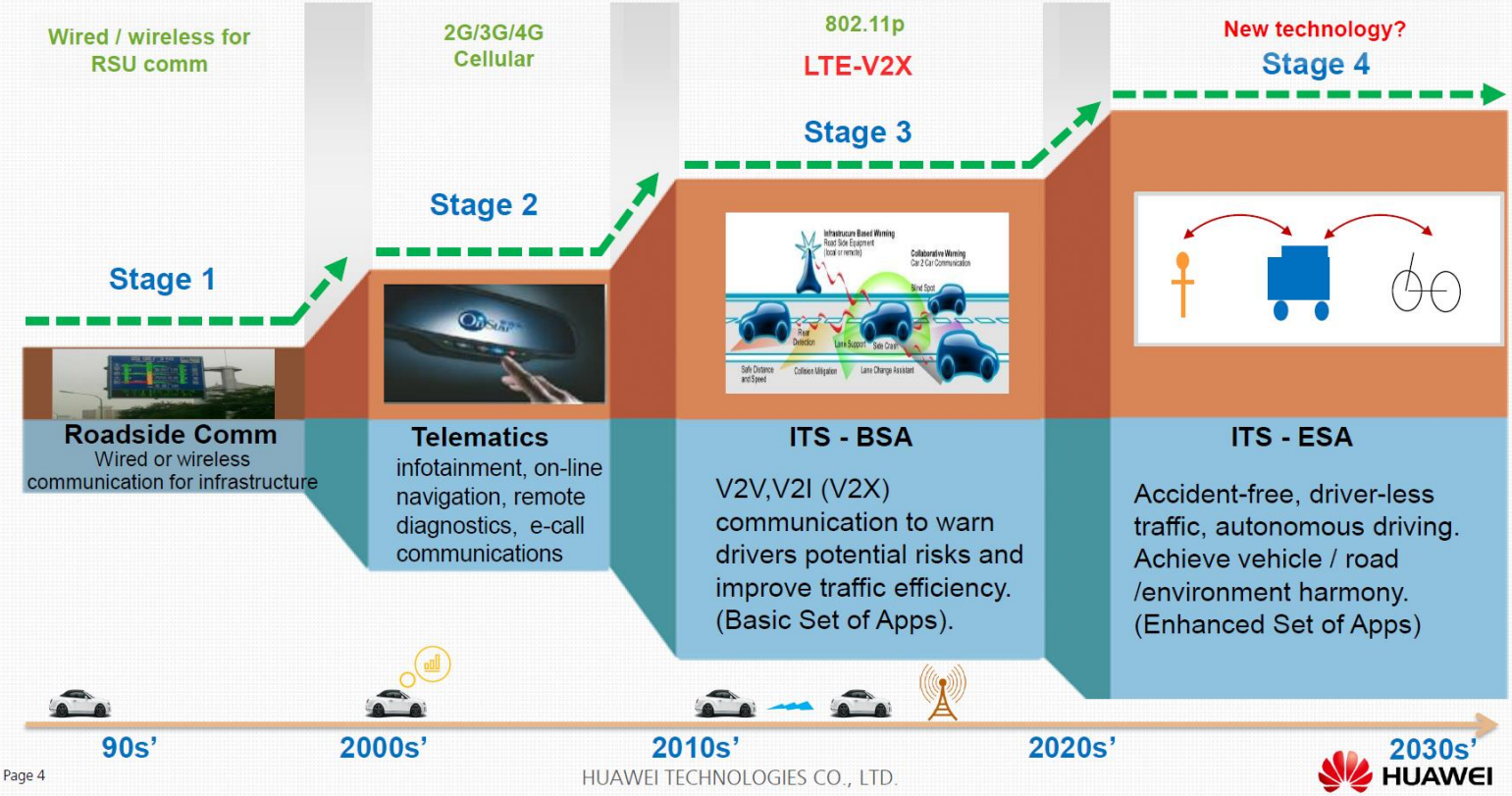
ITS Stages and Key Communication Technologies



HUAWEI TECHNOLOGIES CO., LTD.

HUAWEI

(www.esadealumni.net)

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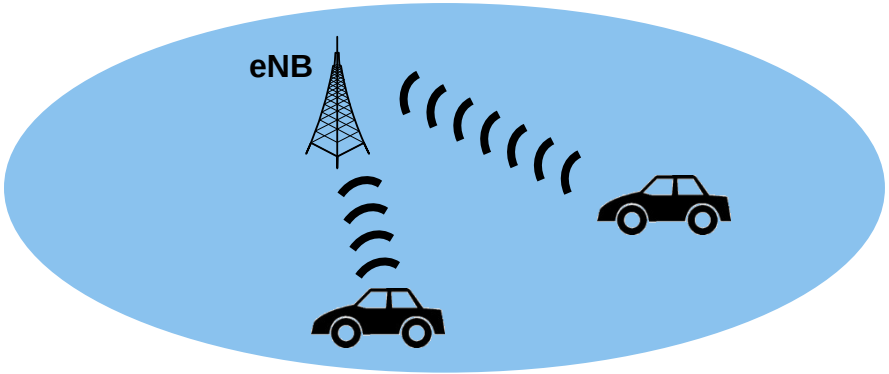
Vehicle-to-Vehicle (V2V) Communication Today

Ad-hoc network
(IEEE 802.11p)

Cellular network
(GSM, UMTS, LTE)



ITS and 802.11p

Intelligent **T**ransportation **S**ystem (ITS)

summarizes applications for traffic management as Car-to-X or navigation. Target is to make

- road user better informed
- traffic safer
- traffic more coordinated

Car-to-X (Vehicle-to-X), communication based on 802.11p

- between vehicles (Car-to-Car / Vehicle-to-Vehicle)
- with roadside units
- with motorcycles
- with bicycles
- with pedestrians (e. g. apps on mobile phones)

ITS and 802.11p

IEEE 802.11p – technical facts

- amendment to IEEE 802.11a standard (published 2010)
- mobile ad-hoc network (WLAN) w/o central infrastructure
- no signalling or authentication
- only broadcast mode on a 10 MHz channel

supports data exchange between high-speed vehicles and between vehicles and roadside infrastructure (required by ITS)

fullfils requirements for saftey applications because of low latency

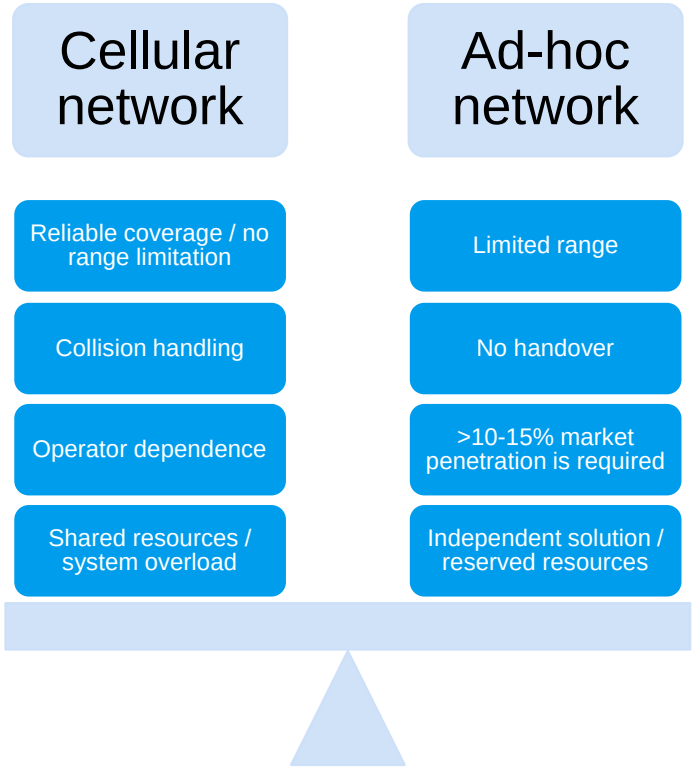
R&S Signal Generators for 802.11p

802.11p Fading Profiles:

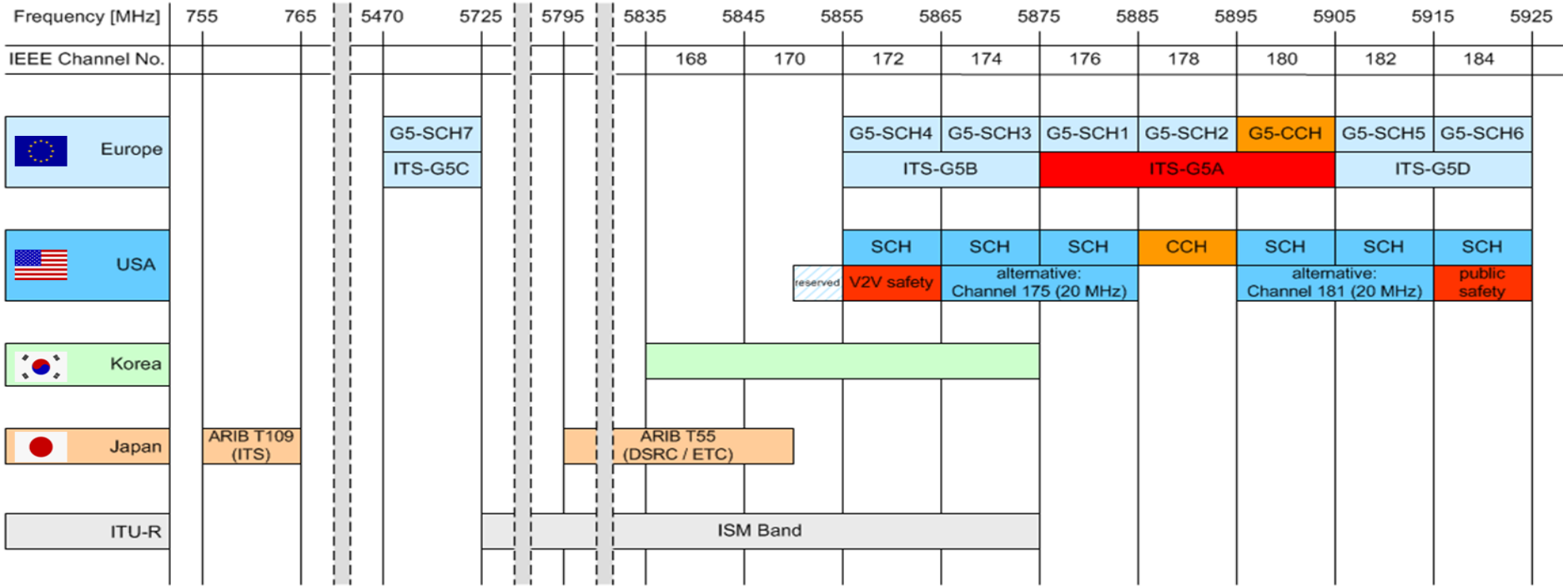
- 802.11p operates in fast moving environments
- Receiver tests under fading conditions are important

- ETSI is adding test cases for fading to the standard
- Same fading profiles as used in ETSI plugfest in Nov. 2013, where R&S took part
- **R&S SMW-200A will support these special fading profiles.**

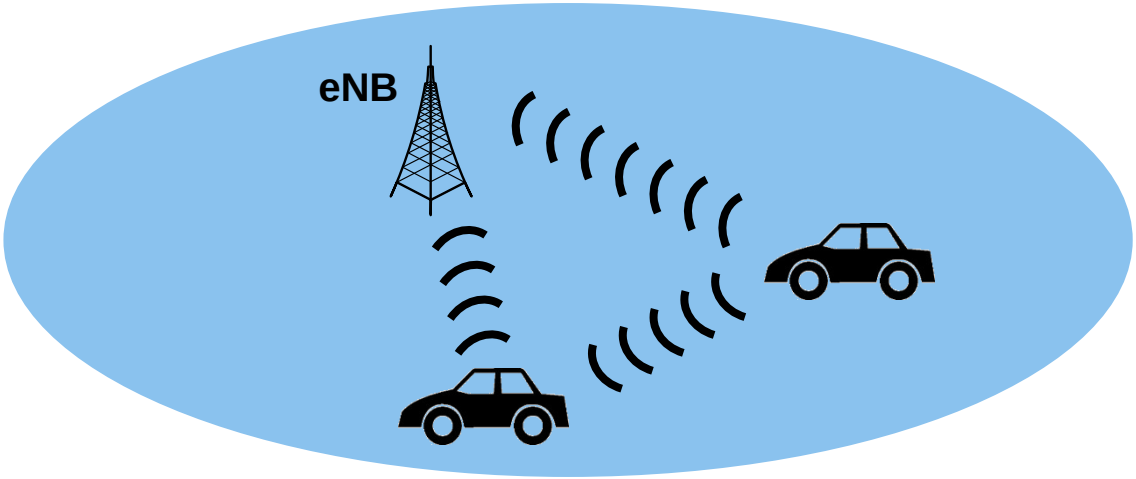
V2V Communication System Comparison



Worldwide Frequency Allocation



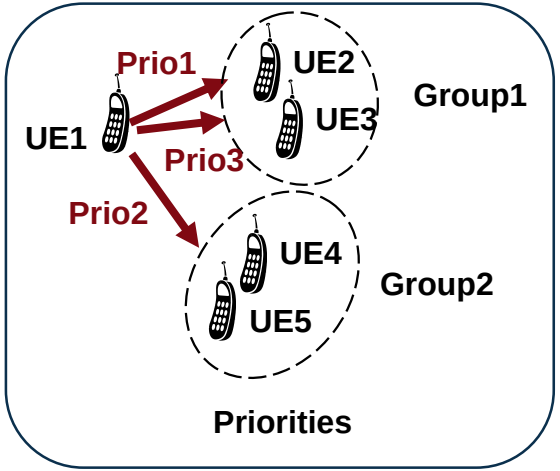
Network-Controlled Ad-Hoc Network



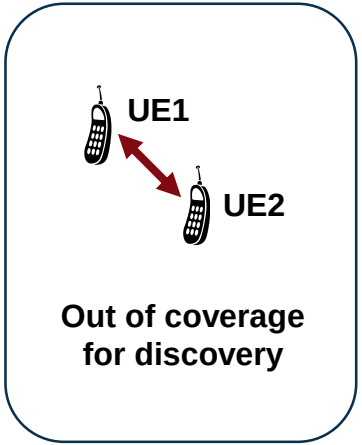
⇨ **Unifies the advantages of both concepts**

⇨ **Allows to select appropriate air interface for application**

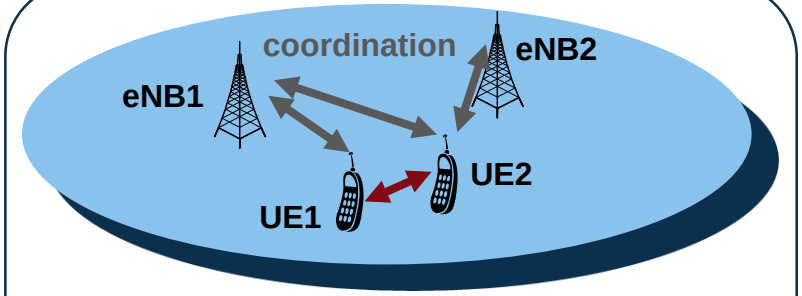
Rel-13 Sidelink enhancements



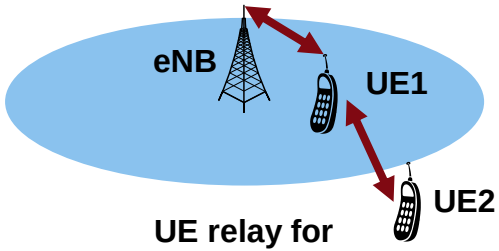
Priorities



Out of coverage for discovery



Inter-carrier / Inter-PLMN
Rel-12 Rx only
Rel-13 Rx and Tx



UE relay for communication (UE1)

Multiple transmissions within one SC period

SC period n

SC period n+1

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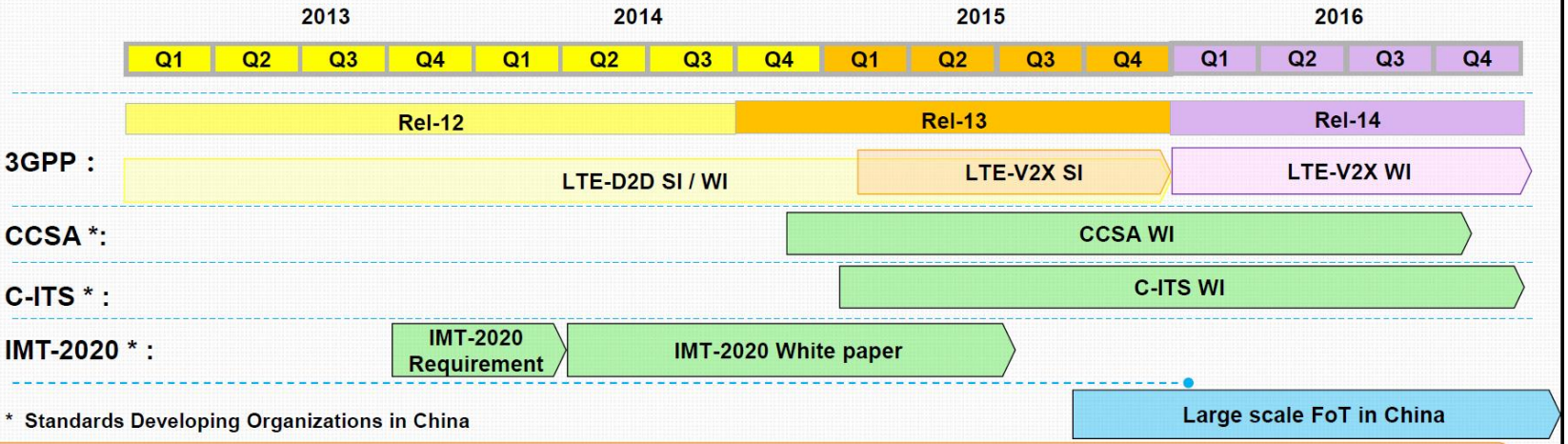
LTE-V2X Standardization Progress



- LTE-D2D has paved the way for V2X communication
- 3GPP SA1 has started Rel-14 LTE-V2X SI from 2015 Feb with most companies' support.
- 3GPP RAN has started LTE-V2X SI from June 2015, V2V part to complete in 2015, the rest in 2016 (Rel-14)
- In China, a series of LTE-V2X SI/WI have been setup at CCSA and C-ITS.
- LTE-V2X is the first step for V2X in 3GPP. When it comes to 5G, even lower latency and higher reliability will be supported

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TS-ITS100 - System software (Europe)

Regulatory tests according to R&TTE* ETSI EN 302 571

Commission communication in the framework of the implementation of the Directive 1999/5/EC of the European Parliament and of the Council of 9 March 1999 on radio equipment and telecommunications terminal equipment and the mutual recognition of their conformity

ESO (1)	Reference and title of the harmonised standard (and reference document)	Reference of superseded standard	Date of cessation of presumption of conformity of superseded standard Note 1	Article of Directive 1999/5/EC
ETSI	EN 302 571 V1.1.1 Intelligent Transport Systems (ITS); Radiocommunications equipment operating in the 5 855 MHz to 5 925 MHz frequency band;Harmonized EN covering the essential requirements of article 3.2 of the R&TTE Directive			Article 3(2)

*European **R**adio equipment and **T**elecommunications **T**erminal **E**quipment (R&TTE) Directive

TS-ITS100 - System software (Europe)

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ITS-G5A Test Cases

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  (contains Adjacent, Non-adjacent and Blocking test case)
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Available on TS-ITS100

Testing to protect other regular radio services

TS-ITS100 - System software (Europe)

Car-2-Car Communication Consortium (C2C-CC)

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- To ensure proper services additionally **performance tests** are required
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- Tests under discussion for
  - **Receiver minimum performance requirements**
    - Receiver sensitivity (under fading conditions)
  - **Decentralised congestion control (DCC) minimum performance requirements**
    - Channel load threshold verification
    - Channel load measurement accuracy
    - Channel load quality under time-varying, multipath propagation conditions

Available on TS-ITS100

Available on TS-ITS100

TS-ITS100 - System software (Europe)

C2C scenario specific channel models

for receiver performance tests under real world conditions (fading)

Rural LOS:
Intended primarily as a reference result, this channel applies in very open environments where other vehicles, buildings and large fences are absent.

Urban Approaching LOS:
Two vehicles approaching each other in an Urban setting with buildings nearby.

Street Crossing NLOS:
Two vehicles approaching an Urban blind intersection with other traffic present. Buildings/fences present on all corners.

Highway LOS:
Two cars following each other on Multilane inter-region roadways such as Autobahns. Signs, overpasses, hill-sides and other traffic present.

Highway NLOS:
As for Highway LOS but with occluding trucks present between the vehicles.

Source: Cohda Wireless

TS-ITS100 - System software (Japan)

Regulatory tests according to ARIB STD-T109

2.1 The test item for the technical requirements for the physical layer

- 2.1.1 Modulation accuracy
- 2.1.2 Reception sensitivity (Packet error rate)
- 2.1.3 Maximum input power for reception
- 2.1.4 Blocking characteristics

Available on TS-ITS100

TS-ITS100 - System software (Japan)

Regulatory tests according to TELEC T257

1 The test item for the technical requirements for the physical layer

- 1.1.1 Frequency tolerance
- 1.1.2 Occupied bandwidth
- 1.1.3 Antenna power tolerance
- 1.1.4 Intensity of spurious or unwanted emissions
- 1.1.5 Transmission data rate
- 1.2.1 Limits of incidentially produced radiation
- 1.3.1 Interference prevention function
- 1.3.2 Carrier sense function
- 1.3.3 Transmission time control function

Available on TS-ITS100

TS-ITS100 - System software (USA)

Certification Operating Council (COC) based on IEEE 802.11-2012

COC TP-80211-TXT-PHY-BV-01	Spectrum mask
COC TP-80211-TXT-PHY-BV-02	Center frequency tolerance
COC TP-80211-TXT-PHY-BV-03	Symbol clock frequency tolerance
COC TP-80211-TXT-PHY-BV-04	Constellation RMS error
COC TP-80211-TXT-PHY-BV-05	Spectral flatness
COC TP-80211-TXT-PHY-BV-06	Center frequency leakage
COC TP-80211-TXT-PHY-BV-07	Transmit power function
COC TP-80211-RXT-PHY-BV-01	Minimum input sensitivity
COC TP-80211-RXT-PHY-BV-02	Adjacent channel rejection
COC TP-80211-RXT-PHY-BV-03	Nonadjacent channel rejection
COC TP-80211-RXT-PHY-BV-04	Maximum input level
COC TP-80211-RXT-PHY-BV-05	Received channel power indicator measurement
IEEE 18.3.9.4	Transmission spurious

Available on TS-ITS100